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MANAGEMENT OF THE ENGINEERING FUNCTION FOR DUAL DEVELOPMENT

DEFENSE SYSTEMS MANAGEMENT SCHOOL,
FORT BELVOIR, VIRGINIA

MAY 1976

DEFENSE SYSTEMS MANAGEMENT SCHOOL

PROGRAM MANAGEMENT COURSE
INDIVIDUAL STUDY PROGRAM

MANAGEMENT OF THE ENGINEERING
FUNCTION FOR DUAL DEVELOPMENT

STUDY PROJECT REPORT
PMC 76-1

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DEFENSE SYSTEMS MANAGEMENT SCHOOL

STUDY TITLE: MANAGEMENT OF THE ENGINEERING FUNCTION FOR DUAL DEVELOPMENT

STUDY PROJECT GOALS: To examine and present two management approaches for engineering during dual development to assist a Program Manager in determining which approach to use for a particular program.

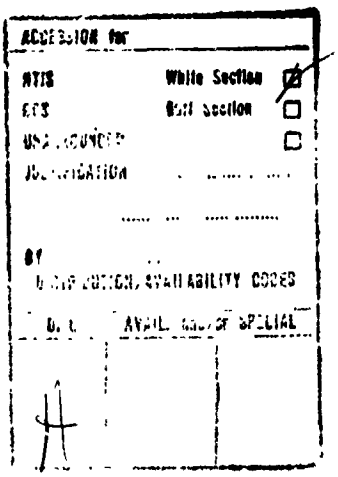
STUDY REPORT ABSTRACT: This study project looked at a dual engineering team approach and a single engineering approach used in dual development programs. It examined criteria used by Program Managers in deciding on their particular approaches, behavioral aspects of each approach, and pros and cons for each.

The main thrust of this report was to present both approaches for a Program Manager to evaluate and make an independent decision as to the most appropriate approach for his/her own program. This study did not conclude that one approach was necessarily better than the other.

KEY WORDS

ORGANIZATION CONCEPTS PROGRAM MANAGEMENT SYSTEMS ENGINEERING MOTIVATION

KEY WORDS: Engineering/Dual Development



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Sheila Riggs Keeling, GS-12, DAFC	PMC 76-1	May 1976

MANAGEMENT OF THE ENGINEERING FUNCTION

FOR DUAL DEVELOPMENT

Study Project Report

Individual Study Program

Defense Systems Management School

Program Management Course

Class 76-1

by

Sheila Riggs Keeling
GS-12 DAFC

MAY 1976

Study Project Advisor
Major D.S. Fujii, USAF

EXECUTIVE SUMMARY

The purpose of this study project is to present to a Program Manager two alternatives for setting up an engineering function within the Program Management Organization on a dual development program. The project looks at various actual programs and how the Program Managers feel about the effectiveness of their engineering functions. The report also sets forth the pros and cons for each alternative (dual engineering teams or a single engineering team) and behavioral aspects of each. Finally, the report defines and evaluates criteria to be used in making a selection of approaches.

The report does not intend to draw any conclusions that one approach is better than another. It merely sets forth information upon which a Program Manager can base a decision as to which approach would better fit his/her particular program. In other words, it is up to each Program Manager to decide which approach is best.

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Section I

INTRODUCTION

The impetus for this study project came from working with an Air Force program office which successfully used a dual engineering team approach on a dual development program. Having worked in a procurement office using both single and dual teams I wondered if other programs had successfully implemented a single team approach in the engineering function. The reason for the wonderment was the problems I had when I had to handle both contracts (single team approach) in the dual development program. If I had problems keeping both contracts separated what kind of problems would one engineering team have in handling major technical aspects of two competing contractors.

I originally started this project with the view that a dual engineering team approach was the only way to handle a dual development program, but after talking to Program Managers who used the single team approach I have decided that there is no best way to set up the engineering function. This report, therefore, does not attempt to draw any conclusions. It merely sets forth some ideas, thoughts, and experiences to enable the new program manager to make his/her own judgemental decision as to which approach would be the best for that program. I have also tried to develop some criteria which one could use in making that determination.

It should be noted that literature on this subject is practically non-existent. Hopefully, this report will help to provide a small filling for that gap.

In my conversations with the Program Managers I asked if they would use the same approach the next time around. One of the Program Managers offered a hybrid arrangement which I have presented as a possible alternative in the summary section of this report.

Section I

INTRODUCTION

Purpose of the Study Project

The purpose of this study project is to present alternatives to a Program Manager for organizing his/her engineering function within the Program Management Office when faced with a dual development program. The two alternatives discussed are a dual engineering team concept and a single engineering team concept.

Areas to be considered are criteria one might use in selecting an approach, benefits and detriments derived from each concept, and the experiences of other Program Managers.

Section I

INTRODUCTION

Organization of the Study Project

The following is an outline of how the two alternatives for setting up the engineering function for dual development will be discussed:

Alternative A

Description: How the engineering function is organized and how it meshes with the entire program management organization.

Benefits/Detriments: Pros and cons for this alternative, including behavioral aspects.

Interview Material: Generalized feedback from those program managers who had this arrangement for their engineering function.

Alternative B

Description: How the engineering function is organized and how it meshes with the entire program management organization.

Benefits/Detriments: Pros and cons for this alternative, including behavioral aspects.

Interview Material: Generalized feedback from those program managers who had this arrangement for their engineering function.

Summary

Criteria for determining which approach to use will be set out in this section as well as an analysis of that criteria.

Conclusions/Implications

Section I

INTRODUCTION

Definitions

Dual Development: As used in the context of this report, dual development is competitive prototyping usually between two contractors, and usually for only a single sub-system which is to be incorporated into a larger system. This competition results in one contractor being chosen through a source selection process to either continue development (alone) or to begin a production contract.

Engineering Function: Since every office considers the engineering function as composed of different areas, for the purpose of this report I will consider it to be composed of systems engineers, software engineers, development/design engineers, and test manager from the Program Management Office.

Program Manager: Because the Air Force and Army entitle their Program Managers differently, for the purpose of this paper, (except for Appendix B, and the Bibliography) Program Manager will be used to refer to that individual who is encharged with responsibility and authority for the program (for the Air Force, this is the System Program Director whereas for the Army it is the Program Manager).

Team: For the purpose of this project report, a team can consist of one individual, if assigned a competing position against another individual.

Section I

INTRODUCTION

Methodology

An interview method was chosen to gather the major portion of the data for this study project. Six program managers or their designated spokespersons were interviewed (three for each alternative concept) to determine what criteria they used in setting up their engineering functions, the problems and benefits they found in their particular approaches, and whether or not they would choose the same approach again. Appendix A sets forth the questions asked in the interviews. Appendix B lists the programs and individuals interviewed.

It should be noted that although research of existing literature revealed a substantial amount of information regarding groups (mainly informal) most of the references quoted one authority (Edgar Schein); therefore, although the List of References contains several sources of information, only those by Edgar Schein were of any real value.

Section II

ALTERNATIVE A

Description

This Alternative, designated "Alternative A," is the single engineering team approach. It is the same engineering organization as in normal, non-dual development programs. An example is set forth on page 8 . It should be noted that this is only an example, that the program managers interviewed did not all have this type of organizaiton, nor does this report attempt to project this example as the way to organize the engineering function.

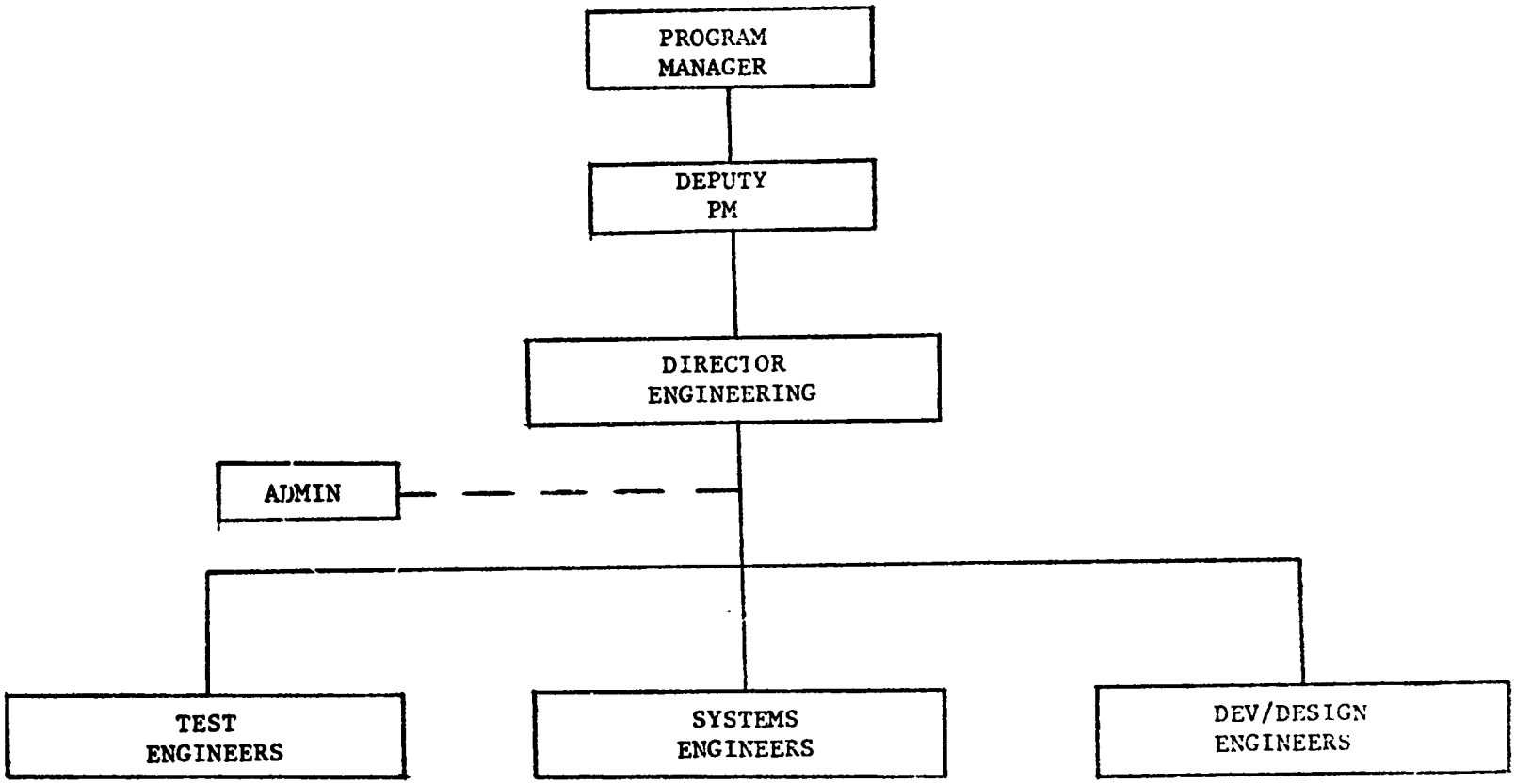
Alternative A consists of an engineering director with all the engineers reporting directly to him/her. The engineers are assigned tasks to perform with no dedication to either of the contractors involved in the dual development program. In other words, if engineer Joe Chaney were charged with the task of reviewing Part I Systems Specifications he would most likely review both contractors' submissions.

Since there is no engineering dedication to contractors, the person responsible for sorting information and drawing conclusions is the engineering director who reports directly to the Program Manager.

Section II

ALTERNATIVE A

Example



Section II

ALTERNATIVE A

Benefits/Detriments

One of the primary benefits of a single engineering team approach is a lack of bias against or identification with the individual competing contractors.[1] This bias/identification does not normally form because the engineers are not dedicated, they are constantly working with first one then the other contractor so they have no chance to form attachments to either.

The single engineering team approach does not foster competition within the program office as does the dual engineering team approach.[2] The engineer is merely one of many working within the engineering division and is not in competition with anyone else. Competition within the program office could be detrimental to the accomplishment of the program goals since it could lead to hostility, lack of cooperation,[3] and even lowered productivity.[4]

A Program Manager may desire some crossfertilization of information about contractors' results and activities to keep everyone aware of where the program stands at any one point in time. Crossfertilization is extremely necessary should an individual have to be away at school or on leave for an extended period, then anyone else within the engineering function could step in and take over his/her position without any loss of time or any loss of corporate memory. The single engineering team is the

[1]This notation will be used throughout the report to designate references. The references are listed by number in the List of References.

only effective way to promote crossfertilization. The dual engineering team concept, due to its very nature, deters crossfertilization. This concept of crossfertilization is not to be confused with that of technical transfusion. Crossfertilization is merely keeping everyone within the program office informed, not transmitting that information to the contractors.

Another benefit of the single engineering team concept is that the engineers are personally committed to the entire program being a success[5] not necessarily a contractor, as is possible with dual engineering teams. Since they normally would not develop a bias toward any particular contractor they can better direct their energies toward the program as a whole.

Because the entire program management office is dedicated to "completing an assigned objective on schedule, within cost and profit goals, and to established standards,"[6] its goals are essentially those of the single team engineering function. Theoretically, "the closer we can get the individual's goals and objectives to the organization's goals, the greater will be the organizational performance;"[7] however, because the single engineering function may be large with the members operating as individuals rather than as members of a group, they are more than likely to be less efficient and creative than those members of dual engineering teams. This, as Edgar Schein has indicated in his research, is due to the fact that groups formed of members who have mutual trust and confidence and have learned to work well together can work more effectively and quickly, and are more creative because of

mutual stimulation provided by other members of the group.[8]

Another potential problem with a single engineering team is technical transfusion.[2] Technical transfusion is the transferring of technical data from one contractor to the other. Since each engineer works with data from both contractors it is easy to "let slip" information to one contractor without realizing that it has taken place. In a dual development, competitive, environment any type of technical transfusion (whether purposeful or unintentional) can be grounds for protest. It is therefore absolutely essential that should one decide to use a single engineering team during dual development that those engineers chosen be individuals who can work with one contractor, then completely divorce themselves from that conversation/review and work with the other contractor without introducing any of the previous information to the other contractor.[5]

There is a possibility in any dual development program that because of the competitive situation there could be some reluctance on the part of the contractors to provide to the Program Management Office certain sensitive information. This could be due to a lack of confidence/trust on the part of the contractor since the same engineers handle both their data as well as their competitor's data and, in the contractor's eyes, there is a great possibility of technical transfusion occurring.[9]

Without the competition within the Program Management Office, the esprit de corps can be lacking thereby affecting morale and the quality/quantity of work.[1]

The following is a summary of the above benefits and detriments.

Section II

ALTERNATIVE A

Summary of Benefits/Detriments

Benefits

1. No bias toward contractors or identification with contractors.

2. No competitive environment in the Program Management Office.

3. Necessary crossfertilization.

4. Personally committed to program.

Detriments

1. Less efficiency.

2. Less creativity.

3. Technical transfusion.

4. Lack of contractor confidence.

5. No esprit de corps.

Section II

ALTERNATIVE A

Interview Material

Each Program Manager interviewed had a unique program; however, the problems and benefits were quite similar. Each (or his predecessor) was responsible for organizing the engineering function in the manner in which he thought best; i.e., single engineering team.

The unanimous reason for the single engineering team approach was the competitive nature of the dual development program. Their reasoning was that with dual engineering teams working independently there could be grounds for contractors to protest unequal treatment - they wanted to balance Government input.

Another determinant of this approach was limited resources. Having to depend upon functional support from other offices where dual teams could not be dictated prevented organization of dual teams. Also, with limited resources within the Program Management Office there were usually not enough engineers to make up two teams, as in the FLIR program which had only one engineer assigned to the program.

The basic responsibilities of the engineering functions were the same as those in non-dual development programs. In other words, the engineers were assigned tasks regardless of contractor involvement as opposed to dual engineering teams which are assigned tasks related to a particular contractor. It would appear that engineers on a single team do twice the work of those on dual teams.

There was some observable reluctance on the part of contractors to provide technical information due to a lack of confidence in the Government system (having the same people look at their data and their competitor's data); however, it was the opinion of the person interviewed that in spite of this lack of confidence the contractors did "put their best foot forward in the competition."[1]

Each program experienced crossfertilization of information which was, in the opinion of the people interviewed, extremely beneficial to program success. At this point in the interviews the difference between crossfertilization and technical transfusion was discussed. All Program Managers indicated that there was no technical transfusion observed. Some of the reasons for this lack of transfusion were policy controls, strict quidelines, and personal involvement by the engineering director.

Engineering changes, a particularly sensitive matter in dual development programs, were handled with each contractor separately, these were not transmitted to the competitor in spite of the fact that the same engineers were working with both contractors. There were no biases observed in the engineering teams. Some programs were able to prevent any possible bias formation through complete Program Management Office participation. There was observed identification with contractors by the on-site test organizations which were organized into dual teams.

As would probably be expected, each Program Manager considered his approach as the most cost effective, schedule effective, and technically efficient.

All of the Program Managers considered the dual engineering team approach as not very effective and one they would not consider using should they ever have another dual development program.

Following is a summary of the interview results.

Section II

ALTERNATIVE A

Summary of Interview Material

INTERVIEW QUESTIONS*	PROGRAMS HELLFIRE	FLIR	MALOR
1	Program Manager	Program Manager	Program Manager
2	(a) Competitive nature of program	(a) Limited resources (b) Use functional support (c) Competitive nature of program	(a) Limited resources (b) Competitive nature of program
3	1 complete engineering team	1 engineer + functional support	4 engineers + 11 laboratory engineers
4	Same as those in non-dual development program office	Same	Same
9	Yes	No	No
10	Yes	Yes	Yes
13	With each contractor separately-not given to competitor	Same	Same
15	Yes	Yes	Yes
16	Worse-would not use it	Same	Same
17	Same approach	Same approach	Hybrid

* The question numbers correlate with the interview questions set forth in Appendix A (note that those questions pertaining to the dual engineering team approach have been eliminated for this list).

Section III

ALTERNATIVE B

Description

This Alternative, designated "Alternative B," is the dual engineering team approach. It is typified by separate engineering teams dedicated to a particular contractor; i.e., responsible for information pertaining to one contractor only. The work done by these engineers is the same as that in the single engineering team with the addition of specialization.

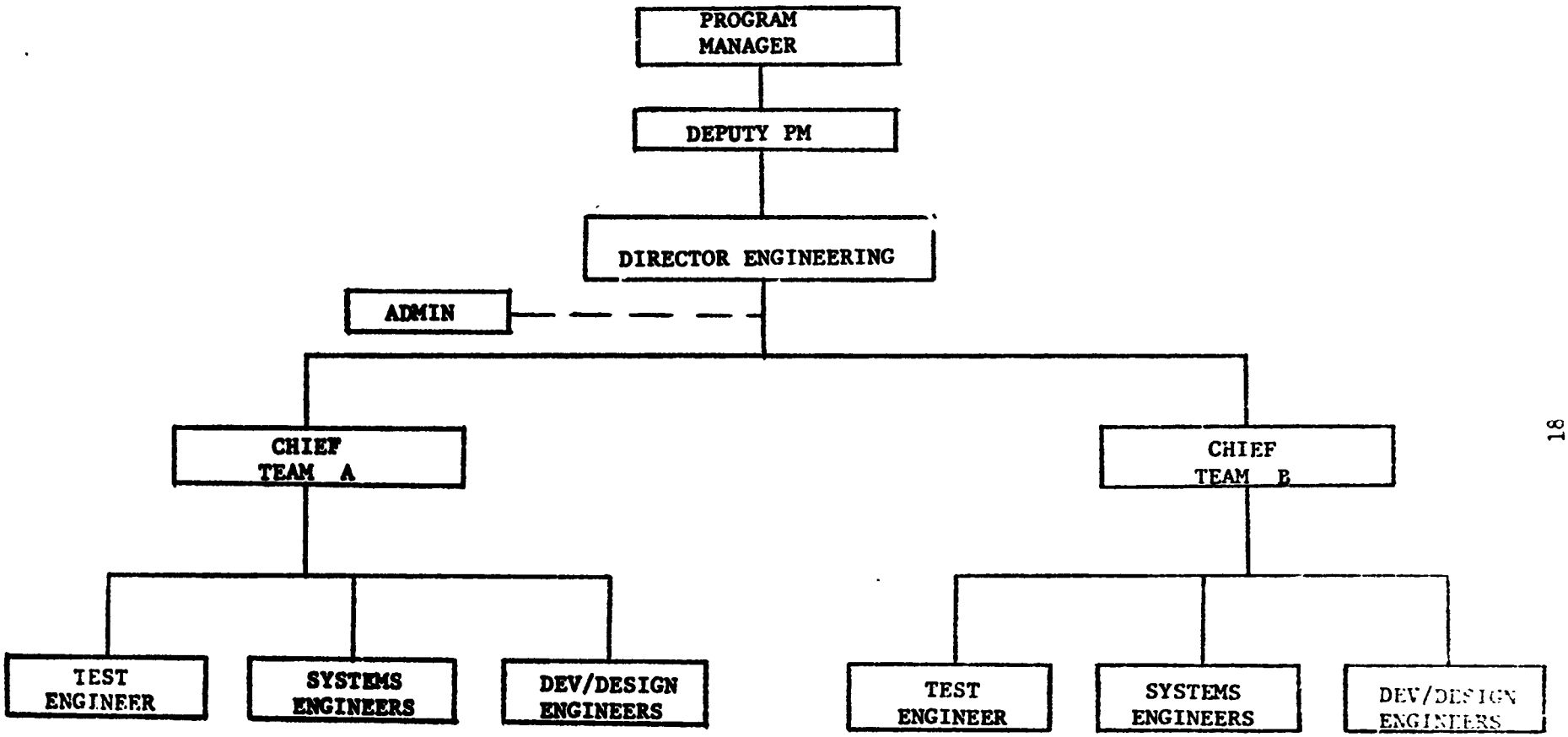
The majority of programs interviewed also had an extra layer of management between the engineers and the Director of Engineering. These individuals operate in the same manner as the Director of Engineering but they are each dedicated to a particular contractor. These individuals are working managers and also filters/organizers of information for the Director of Engineering. The Director is then tasked with the further responsibility of filtering out biases from data on its way to the Program Manager.

An example of this dual engineering team concept is set forth on the following page. Again, as in the single engineering team concept, it should be noted that this is merely an example.

Section III

ALTERNATIVE B

Example



Section III

ALTERNATIVE B

Benefits/Detriments

Competitive groups, as we can label the dual engineering teams because they are in essence competing, can be more productive than a single engineering team. There is evidence to the fact that cohesive groups are more productive if the groups are not in conflict with management.[4] In the dual engineering team concept, the goals may not be identical to those of management but these goals are certainly not in conflict.

A dual team approach can foster a closer working relationship between the Government and the contractor due to an increased confidence level. The contractor is aware of the team dedication and is more willing to be open with data knowing there is a good possibility the data will not get into the hands of his/her competitor.[10]

Dual engineering teams work faster and more effectively mainly because they are totally devoted to one objective. These groups are usually formed of members who have learned to work well together, if management is doing a proper job, and therefore work more efficiently and quickly. As was previously stated in the discussion of detriments of the single team approach, these groups are also more creative due to the mutual stimulation members provide each other.[8] Another reason for the effectiveness of dual engineering teams is that each team has a working boss and are therefore more receptive to orders from him/her than from the Director of Engineering.[4]

One of the primary benefits of the dual engineering team concept is the prevention of technical transfusion. (See Section II for further discussion of technical transfusion). Since each team is totally devoted to one contractor and isolated from the other there is little opportunity for technical transfusion. The added management layer also serves as a filtering device to prevent technical transfusion. Should there be a requirement for some sort of transfusion, the next level, Director of Engineering, is in the position to filter down that information.

Morale, or esprit de corps, is increased due to the fact that each team is usually smaller than one single engineering function and, "is held together through internal cohesiveness ...," and is characterized by an optimistic "we're going to win" attitude.[4]

One of the basic problems of dual engineering teams is the development of bias and identification. Since an engineer works with one contractor all the time and is aware of the competitive nature of the program it is very easy for him/her to begin to identify with that contractor and develop a bias against the other. This problem is typified by the engineer who says, "We're going to win this competition," or "My contractor is better than your contractor."

Conflicts and rivalry, loss of perspective, loss of cooperation and lack of communication can also result. The following excerpt from Edger Schein's, Process Consultation, aptly describes what happens between competing groups:

1. Each group begins to see the other groups as the enemy, rather than merely a neutral object.

2. Each group begins to experience distortions of perception: it tends to perceive only the best parts of itself, denying its weaknesses, and tends to perceive only the worst parts of the other group, denying its strengths. Each group is likely to develop a negative stereotype of the other ("they don't play fair the way we do").

3. Hostility toward the other group increases while interaction and communication with the other group decrease; thus it becomes easier to maintain negative stereotypes and more difficult to correct perceptual distortions.

4. If the groups are forced into interaction ... group members tend to listen only for that which supports their own position and stereotype.[3]

According to Schein, groups can become so committed to their own goals (their contractor winning the competition) that they do become competitive with the other group and can become a liability to the organization (Program Management Office) as a whole.[7]

As was mentioned above, the dual engineering team can have a different goal than the program. The program goal is to get the best product, on time, for the best cost but the team which has developed an identification with a contractor can have as its goal that contractor (his/her contractor) winning the competition. Since this contractor may not be the one which

can deliver the best product, on time, and at least cost, this goal would conflict with the program goal.

A final difficulty with dual engineering teams is that crossfertilization is difficult to obtain. Since the two teams work separately with their respective contractors the only person who knows what both are doing is the Director of Engineering. To replace anyone in one team with someone from the other team would require time to reorient his/her thinking and effort by the Director of Engineering to educate that individual on the new side of the program (his contractor's competitor).

The following is a summary of the above benefits and detriments.

Section III

ALTERNATIVE B

Summary of Benefits/Detriments

Benefits

1. Competition can be productive.

2. Closer relationships with contractors, more confidence.

3. Faster and more effective.

4. Prevention of technical transfusion.

5. More esprit de corps, better morale.

Detriments

1. Development of bias and identification.

2. Conflicts and rivalry.

3. Loss of perspective.

4. Lack of cooperation/communication.

5. Goal differences.

6. Crossfertilization difficult.

Section III

ALTERNATIVE B

Interview Material

As was true in the single engineering team concept, the Program Manager made the decision as to the organization of his engineering function.

Some of the criteria used were similar to that used by the Program Managers with a single team approach, such as resources and the sensitivity of the competitive information. However, the resource criteria used here was enough resources to support two teams, both authorized slots and money. These Program Managers also felt that protests could be better avoided by having separate teams which could not possibly transfuse any information between competitors.

Another criteria used was the scope of work involved. If there were a common specification to which both contractors built there would be no need for dual teams, one team could handle the work easily.

Another consideration was trade offs. One has to make a trade off between having an individual who is thoroughly familiar with one contractor's system or crossfertilization where everyone is slightly familiar with all the systems but no one is an expert.

Each office had a Chief of Engineering with, (what the Air Force calls Program Manager), two team leaders reporting to him. These team leaders were only allowed to crossfertilize on those matters the Chief of Engineering thought appropriate.

Basic responsibilities of the teams were similar to those of the single teams with the addition of specialization; i.e., dedication to one contractor. These teams were all told, and retold constantly, to work independently.

The major problem faced by all the Program Managers was that of group identification with the respective contractors. There was some "halo" effect, with the contractor who was doing well the team had a tendency to highlight good points and not mention bad. Some group members got defensive when "their" contractor was being criticized, especially when the person doing the criticizing had information to the contrary. One Program Manager tried to solve this problem by continuously redefining team leaders' roles and by constantly advising people not to get personally involved. Per one Program Manager, a basic consideration is to choose objective people who can put things in perspective.[11]

The majority of Program Managers observed some inter-group conflicts but none that could not be easily taken care of by either the team leaders of the Chief of Engineering.

Only one program interviewed maintained the dual team approach throughout the source selection process. Most of the Program Managers disbanded the teams and let everyone return to their specialties. The identification problem did persist but the Chief of Engineering was always able to remove the bias; therefore, it cannot be said that the identification problem slanted source selection.

Engineering changes did not seem to pose any problems for any of the programs. Nor were there any problems in interfacing with other functional areas. All engineers were treated the same regardless of the contractor with which they worked.

All the Program Managers felt that the dual engineering team concept enabled them to get a sound technical product on contract, on schedule; however, they did not all agree that it was a cost effective way of organization.

There was unanimous agreement that the dual engineering team concept was the best approach for a dual development program, in fact, one Program Manager went so far as to say "it was the only feasible approach."[10] As could be expected from the above discussion, they would all use the same approach if given another dual development program.

Following is a summary of the interview results.

Section III

ALTERNATIVE B

Summary of Interview Material

INTERVIEW QUESTIONS*	PROGRAMS		
	LORAN	AWACS	TACAN
1	Program Manager	Program Manager option inconjunction with prime contractor	Program Manager
2	(a) Scope of work (b) Resources (c) Tradeoffs	(a) Sensitivity of information, prevent crossfertilization	(a) Prevention of technical transfusion-sensitivity of competitive situation
3	Chief of Engineering over 2 individuals (each titled Program Manager) heading 2 separate teams	Same	Same
4	Identical to normal program office but contractor dedicated and working independ-ently	Same	Same
5	Independent but some crossfertilization	Independent	Independent
6	Independent	Same	Same
7	Yes	Yes	Yes
8	Yes	No	Yes
11	No	Yes	No
12	No effect	No effect	No effect
13	Loosely	No problem	Loosely
14	No problems	Same	Same

INTERVIEW QUESTIONS*	PROGRAMS LORAN	AWACS	TACAN
15	Yes	Yes	Yes
16	Best approach	Same	Same
17	Same approach	Same	Same

* The question numbers correlate with the interview questions set forth in Appendix A (note that those questions pertaining to the single team approach have been eliminated from this list).

Section IV

SUMMARY

Criteria

Before a Program Manager decides which approach to use in setting up the engineering function for a dual development program some of the things which must be considered are:

(a) What resources are available, both authorized manpower, functional support and money? If functional support is to be used, what control can be exercised over them?

(b) Do you want individuals to be thoroughly familiar with one contractor's system or do you desire crossfertilization? In other words, which is most important to you?

(c) What is the scope of the work? Could it be handled by one group of people?

(d) What type of individuals are available for your program? Are they objective, petty, joiners, loners, etc.?

(e) How sensitive is the competitive nature of your program?

(f) What type of contractors will you be dealing with? Are they the kind who need the dedicated Government team in order to provide necessary competitive technical data?

Section IV

SUMMARY

Conclusions/Implications

As was stated in the introduction this report does not draw any conclusions as to which engineering approach is better than the other, it merely presents data to aid the Program Manager in making his/her own judgemental decision. It should be pointed out that there are other alternatives to the single and dual engineering team approaches. One such alternative was proposed during an interview: Set up the engineering function as in a single team concept but have a Systems Program Manager for each competing system reporting directly to the Program Manager.[10]

It would appear that any approach chosen, based upon the criteria set forth herein, would prove to be effective. The only word of advice is to tailor the organization to the particular program and to be flexible.

APPENDIX A

Interview Questions

1. Which individual was responsible for making the determination of dual or single team concept for dual development?

2. Are you aware of the criteria, if any, for making this determination?

3. What was the organization of the engineering function?

4. What were the basic responsibilities of the engineering functions?

5. If you had dual teams, did they operate independently of each other or were there exchanges of ideas, plans, contractor experiences or contractor achievements?

6. If you had dual teams, were they told to operate independently or jointly?

7. If you had dual teams, did you observe the teams identifying with the contractor they were required to monitor?

8. If you had dual teams, did you observe any inter-or-intra-group conflicts as a result of the competition?

9. If you had a single team, did you observe any reticence on the part of the contractors to provide information due to the sensitivity of the competition?

10. If you had a single team, did you observe any cross fertilization (technical or otherwise) due to the same people handling both contractors' data?

If you had dual teams, did you maintain this approach during source selection evaluation?

12. Reference question 11, could you comment upon the effects of this team approach on the evaluation; i.e., were the evaluations objective or biased toward the respective contractor?

13. How were engineering changes handled?

14. If you had dual teams, how did these teams interface with other program management organization functions? Were the individuals treated the same regardless of which contractor they monitored?

15. Would you say your approach was effective cost, schedule and technical areas considered?

16. What is your opinion of using a dual team approach? Do you think it is better or worse than a single team approach?

17. If you had a new dual development program, which approach would you use and would it be the same one with which you had experience?

18. Do you have any comments about anything I have covered or did not cover?

APPENDIX B

Programs Interviewed

Alternative A (Single Team Approach)

1. **Program:** MALOR

   Service: Army

   Person Interviewed: COL. DeAngelo
   Deputy Program Manager

2. **Program:** Forward Looking Infrared Radar

   Service: Air Force

   Person Interviewed: MAJ. Ken Wheeler
   Program Manager

3. **Program:** HELLFIRE

   Service: Army

   Person Interviewed: Mr. Marvin Carroll
   Lead Engineer

Alternative B (Dual Team Approach)

1. **Program:** LORAN

   Service: Air Force

   Person Interviewed: COL. Gerald Samos
   System Program Director

2. **Program:** TACAN

   Service: Air Force

   Person Interviewed: LTC Fred Nomer and CPT Ron Hubbard
   Program Manager

3. **Program:** AWACS (Radar portion)

Service: Air Force

Person Interviewed: LTC Ray Macmillan
Program Manager

List of References

1. HELLFIRE Program *.

2. MALOR Program *.

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* See Appendix B for further information regarding these programs.